Karaelmas Fen ve Mühendislik Dergisi
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Research Article
Geliş tarihi / Received : 14.02.2017
Kabul tarihi / Accepted : 30.03.2017

An Investigation on the Quality of Natural Spring Waters in Zonguldak Province (Turkey)

Zonguldak İlindeki Doğal Kaynak Sularının Kalitesi Üzerine Bir Araştırma (Türkiye)

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Abstract

In this study, an investigation on the quality of 49 natural spring water samples collected from the Zonguldak province was carried out. Temperature (*T*), electrical conductivity (*EC*), *pH* and radioactivity levels of water samples and the correlations between them were investigated.

Keywords: Natural spring waters, Temperature, pH, Conductivity, Gross alpha and beta, Zonguldak

Öz

Bu çalışmada, Zonguldak ilinden toplanan 49 doğal kaynak suyu örneklerinin kalitesi üzerine bir araştırma yapılmıştır. Su örneklerinin sıcaklık (*T*), iletkenlik (*EC*), *pH* ve radyoaktivite özellikleri ile bunlar arasındaki korelasyonlar incelenmiştir.

Anahtar Kelimeler: Sıcaklık, Doğal kaynak suları, pH, İletkenlik, Toplam alfa ve beta, Zonguldak

1. Introduction

Water is the most important natural resource, which is an essential compound for all living things. Therefore, measurement of *T*, *pH*, *EC* physico-chemical parameters (Oyem et al. 2014; Yılmaz and Koç 2013; Kumar et al. 2017) and radioactivity levels in drinking waters (Kobya et al. 2015; Turgay et al. 2016; Korkmaz and Ağar 2016) are important for the healthcare. The temperature of drinking water resource should close to temperature of environment, and not to be at high temperature that changes its taste, smell and color, and increase the corrosion problems (Oyem et al. 2014). The *pH* indicates the hydrogen concentration in the water, which defines its acidity and alkalinity. Dissolved gases and salts affect the *pH* value and remove it from its natural value that is 7. A water sample with a $pH < 7$ is considered acidic. Acidic waters are soft and corrosive. Therefore, they can leach metals such as copper, zinc, and lead from pipes causing elevated levels of toxic metals in the water (Absolute Water Treatment 2011). On the other hand, that *pH* which is above a value of 8.0 in drinking water is a disadvantage in order to treat it with chlorine (Oyem et al. 2014). The World Health Organization (WHO) recommends that *pH* in drinking waters to be between 6.5 and 8.5 (WHO 2011).

The *EC* is the measure of ionic component dissolved in the water and therefore, it is an indicator of total dissolved matter amount (Yılmaz and Koç 2013). According to Turkish Standards (TS) the recommended *EC* values for spring waters is 650 μScm^{-1} (TSE 1997). On the other hand, the natural radioactivity in drinking waters arises from the alpha and beta emitters. Underground waters are in contact with different geological formations and the natural radionuclides can be dissolved into the water. Natural radionuclides in drinking water generally come from primordial radionuclides ^{232}Th and ^{238}U series and ^{40}K. The measurement of gross alpha and beta activity concentrations attempts to determination of the radioactivity level in drinking waters. The recommended values for the gross alpha and beta activity concentrations in drinking waters are 500 mBq L^{-1} and 1000 mBq L^{-1}, respectively (WHO 2011). Some published results for the measurement of gross alpha

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and beta activity concentrations in water samples can be found in the literature (Kobya et al. 2015; Turgay et al. 2016; Korkmaz and Ağar 2016; Aytekin and Bayraktaroğlu 2016). Whiles the most common alpha emitter radionuclides are ^{226}Ra and its decay product ^{222}Rn of ^{238}U series the beta emitter radionuclides are ^{40}K and the decay product ^{228}Ra of ^{232}Th series. The ^{226}Ra ($t_{1/2}$=1620 y) and ^{228}Ra ($t_{1/2=}$5.75 y) can easily dissolve and travel within the aquifer, which are the most radiotoxic and dangerous radionuclides in case of ingestion (Altınkulaç et al. 2015). Radioactive ^{40}K, which is a small fraction of natural ^{39}K, behaves as the other potassium isotopes in the body after ingestion. Some published results can be found in the literature for the analysis of ^{226}Ra, ^{228}Ra and ^{40}K activity concentrations in drinking waters (Altınkulaç et al. 2015; Ajayi and Adesida 2009; Agbalagba et al. 2015).

Considering the reasons mentioned above, for the development of civilization, the amount and the evaluation of underground waters and their qualities are important in the respect of strategic planning and the development of the water resources (Al-Harbi et al. 2006). For this aim, to determine the radiological characters of the natural spring waters in the center of Zonguldak and its districts Kozlu, Ereğli, Kilimli and Çaycuma the gross alpha and beta activity concentrations were measured in the collected water samples from the water reservoirs of these places. The correlation between the measured alpha and beta activity concentrations, and some statistics about these concentrations were also published (Aytekin and Bayraktaroğlu 2016). In the present study, the measured parameters *T*, *pH* and *EC* were analyzed and the correlations between, *T* and *pH*, *pH* and *EC*, and gross alpha and *EC* and gross beta and *EC* were investigated.

2. Material and Methods

Zonguldak province is located between 41°00' and 41°59' N latitude and between 31°29' and 32° 29' E longitude with a population of 595.907 as of 2015 and an area of 3.310 km^2. Some information about the geology of the region can be found in the study of (Karacan and Okandan 2000). To measure the *T*, *pH*, *EC* parameters and gross alpha and beta activity concentrations, 49 samples were collected from the spring water reservoirs in Zonguldak province. The *T*, *pH* and *EC* parameters of the samples were measured while collecting the samples by using the Logger Pro 3.9 software with Surface Temperature Sensor, Vernier *pH* sensor and conductivity probe. The measurement system is seen in Figure 1. On the other hand, the gross alpha and beta activity concentration measurements in the samples were made by using standard EPA 900.0 method (Aytekin and Bayraktaroğlu 2016).

3. Results and Discussion

In this work, the measured *T*, *pH* and *EC* values in 49 water samples collected from natural spring water reservoirs in central Zonguldak and its districts Ereğli, Kozlu, Kilimli and Çaycuma were analyzed. The measured *T*, *pH, EC* values and gross alpha and beta concentrations were shown in Table 1. The sample places and their coordinates were also given in Table 1. The temperatures of water samples were found to be close to the environment temperatures, and therefore we have considered that no change is occurred in taste, smell and corrosion of water samples (Oyem et al. 2014). As it is seen in Table 1, the *T*, *pH* and *EC* values are in the ranges of 15.44-26.21 °C, 3.4-7.2 and 35.13-1319 µS

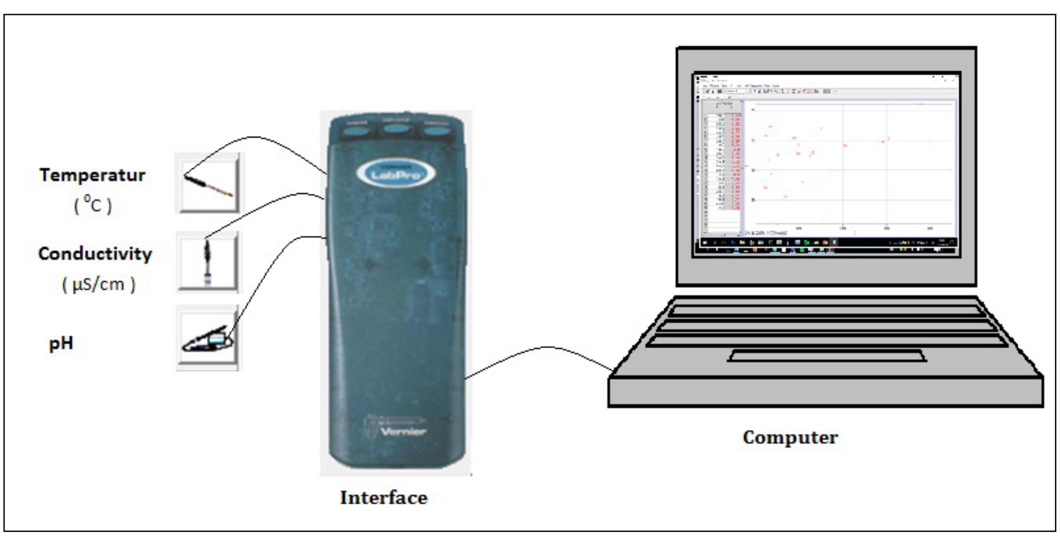

Figure 1. The measurement system.

Table 1. The sample locations and coordinates of natural spring waters, *T*, *pH*, *EC*, gross α and gross β activity concentrations in the water samples in Zonguldak Province (Turkey)

Places	Latitude	Longitude	T (°C)	pH	EC (µS cm^{-1})	Gross α (mBqL^{-1})	Gross β (mBqL^{-1})
Zonguldak							
1. Ontemmuz-1	N41° 26' 10,5"	E031° 46' 25,9"	19,04	4,10	135,9	11,60	69,80
2. Ontemmuz-2	N41° 26' 23,9"	E031° 46' 30,8"	18,2	5,57	264,3	35,00	106,20
3. Çaydamar	N41° 25' 1"	E031° 48' 2"	18,16	4,57	35,13	14,20	33,70
4. Rüzgarlımeşe	N41° 27' 28,1"	E031° 48' 22,7"	18,56	5,59	254,4	18,90	44,60
5. Milli Egemen	N41° 19' 57,1"	E032° 02' 44,5"	21,46	6,05	608,7	57,00	48,30
6. *Çayköy*	N41° 20' 32,0"	E032° 01' 51,6"	25,58	5,91	800,7	74,40	78,70
7. Karaman-1	N41° 22' 48,01"	E031° 57' 23,8"	19,4	5,80	409,5	36,80	40,00
8. Karaman-2	N41° 22' 153"	E031° 57' 8,4"	20,89	7,18	759,1	52,60	122,00
9. Sapça	N41° 25' 08,6"	E031° 55' 49,7"	21,54	5,52	103	9,70	23,10
10. Mevlana	N41° 25' 46,2"	E031° 53' 32,4"	20,76	5,34	64,1	2,90	30,10
11.Elvanpazar1	N41° 25' 44,5"	E031° 52' 19,1"	22,44	5,47	251,9	13,40	15,40
12. Elvanpazar2	N41° 25' 47"	E031° 51' 43,8"	18,18	5,55	192,9	24,90	20,90
13. Terakki-1	N41° 26' 47,6"	E031° 46' 58,3"	16,59	5,86	195,4	9,60	126,50
14. Terakki-2	N41° 26' 68,6"	E031° 46' 64,9"	22,71	6,46	68,36	8,70	69,30
15. Terakki-3	N41° 26' 48,8"	E031° 46' 35,1"	20,2	4,62	215	18,70	77,70
16. Asma	N41° 27' 01,0"	E031° 50' 07,4"	20,49	6,06	181,2	17,00	37,20
Ereğli							
17. Ömerli	N41° 10' 02,1"	E31° 25' 51,9"	21,02	6,21	331,5	22,50	23,70
18. Ören	N41° 16' 41,4"	E031° 30' 20,6"	22,42	6,17	77,86	5,10	70,50
19. Aydınlar	N41° 16' 01,7"	E031° 33' 49,6"	22,62	6,23	140,2	18,50	98,40
20. Soğanlı	N41° 18' 27,9"	E031° 31' 29,6"	18,33	5,99	69,21	6,00	53,20
21. Gökçeler	N41° 20' 27,2"	E031° 32' 09,6"	16,83	4,25	117,1	10,20	44,00
22. Terziköy	N41° 19' 27,2"	E031° 33' 40,1"	20,63	5,84	102	11,40	33,70
23. Sücüllü	N41° 19' 49,4"	E031° 36' 07,1"	18,49	5,91	93,14	6,40	51,10
Kozlu							
24. Seyfetler	N41° 22' 04,5"	E031° 39' 31,4"	23,24	6,39	297,5	19,10	53,10
25. Ilıksu	N41° 23' 53,1"	E031° 41' 03,4"	20,59	6,15	45,55	9,90	37,60
26. Günbatımı	N41° 24' 42,6"	E031° 41' 24,9"	23,96	5,96	580,6	123,30	210,90
27. Esenköy	N41° 24' 34,7"	E031° 41' 32,2"	22,5	4,43	43,15	4,10	20,80
28. Değirmen1	N41° 25' 04,0"	E031° 43' 20,6"	15,44	4,88	340,7	21,60	36,70
29. Değirmena2	N41° 24' 49,5"	E031° 43' 06,4"	22,15	4,87	75,73	26,30	41,10
30. İncivez	N41° 26' 47,2"	E031° 45' 26,7"	21,56	3,38	307,9	10,30	86,80
Kilimli							
31. Soğuksu	N41° 29' 04,7"	E031° 50' 23,8"	16,76	5,63	358,5	18,40	98,00
32. Balıkçı Bar.	N41° 29' 39,8"	E031° 50' 28,4"	21,7	5,09	143	9,40	19,60
33. Radaraltı	N41° 29' 37,1"	E031° 50' 55,6"	26,21	5,18	263,3	22,30	43,60
34. Karadon-1	N41° 28' 58,3"	E031° 51' 00,5"	15,66	5,25	136,2	16,20	83,80
35. Karadon-2	N41° 28' 45,6"	E031° 51' 36,9"	16,79	5,27	100,4	31,90	83,40
36. Gelik-Ayiçi	N41° 28' 31,7"	E031° 53' 26,5"	21,24	5,95	143,6	15,20	34,30
37. Çatalağzı	N41° 29' 43,3"	E031° 51' 39,2"	22,01	5,93	115	15,40	27,60
38. Muslu-1	N41° 31' 01,4"	E031° 54' 40,5"	20,7	5,66	369,2	21,40	34,30

Table 1. Cont.

Places	Latitude	Longitude	T (°C)	pH	EC (µS cm^{-1})	Gross α (mBqL^{-1})	Gross β (mBqL^{-1})
39. Muslu-2	N41° 37' 30,1"	E031° 56' 10,1"	21,72	6,02	503,8	32,20	92,60
40. Göbü	N41° 31' 45,5"	E031° 57' 23,9"	20,87	5,81	302,3	21,70	40,10
41. Türkali-1	N41° 32' 22,4"	E031° 58' 20,0"	18,07	5,85	328,6	29,00	97,30
42. Türkali-2	N41° 32' 33,31"	E031° 58' 45,8"	20,45	5,74	295,1	15,40	27,60
Çaycuma							
43. Filyos	N41° 33' 04,2"	E032° 00' 20,8"	17,47	5,79	355,5	34,70	40,20
44. Gökçeler	N41° 38' 08,2"	E032° 04' 20,7"	22,14	5,63	259,5	11,30	97,00
45. Çömlekçi	N41° 31' 37,6"	E032° 04' 52,3"	21,89	5,75	173,4	28,00	68,80
46. Saltukova	N41° 30' 08,6"	E032° 05' 51,0"	25,31	5,93	1044	77,20	63,90
47. Perşembe1	N41° 24' 58,5"	E032° 09' 00,3"	23,07	6,02	722,1	70,70	116,80
48. Nebioğlu	N41° 26' 19,9"	E032° 14' 24,8"	23,71	5,92	858,8	84,50	73,50
49. Perşembe2	N41° 25' 18,5"	E032° 10' 33,4"	21,89	5,69	1319	170,50	244,30

cm^{-1}, respectively. As it is seen in Figure 2, the water samples generally have the *pH* values that are below the lower limit 6.5 (WHO 2011), and therefore, they are not acceptable for drinking. Only, 8th sample (Karaman2) has the *pH* value about 7, which is in the range of recommended limit. In the case of conductivity levels, except the Çayköy, Karaman2, Saltukova, Perşembe1, Perşembe2 and Nebioğlu the other water samples have the conductivity levels lower than 650 µS cm^{-1} and they are acceptable for good water (TSE 1997). Investigations have shown that there were no meaningful correlations between the *T* values and *pH* and *EC* values. On the other hand, a positive but weak correlation coefficient (R=0.25) was found between the *pH* and *EC* values (Figure 3). However, the *EC* values were found to be higher in the places where the *pH* is around 6 than the other places.

In this study, the correlations between the *EC* values and gross alpha/ beta activity concentrations were also analyzed. Whereas the correlation coefficient between the *EC* and gross alpha activity was found to be R=0.88 (Figure 4) the correlation between *EC* and beta activity was found to be R=0.56 (Figure 5). Generally, the alpha activity concentrations are higher where the *EC* values are higher. In the earlier studies, good correlations were found between ^{226}Ra contents and *EC* values in drinking water samples (Tabar and Yakut 2014; Shivakumara et al. 2014). Therefore, we may conclude that the high correlation between the gross alpha activity concentrations and *EC* values is the indicator of the ^{226}Ra contents of our water samples. Apart from this result, the positive correlation between *EC* values and gross beta activity concentrations may lead to a conclusion that

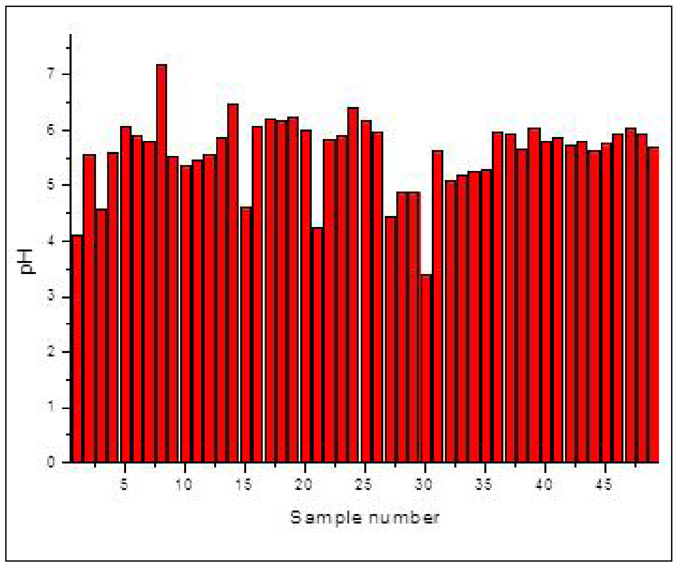

Figure 2. The distribution of *pH* values in spring water samples in Zonguldak province (Turkey).

the significant contribution to the beta activity was come from ^{40}K and ^{228}Ra contents in our water samples.

4. Conclusion

In our previous work (Aytekin and Bayraktaroğlu 2016), it was found that the natural spring water samples collected from Zonguldak province are acceptable for drinking and concluded they have good radiological quality. In the present work, we have found that the same water samples generally have the *pH* values, which are lower than the lowest limit 6.5 recommended by WHO. Therefore we may conclude that the

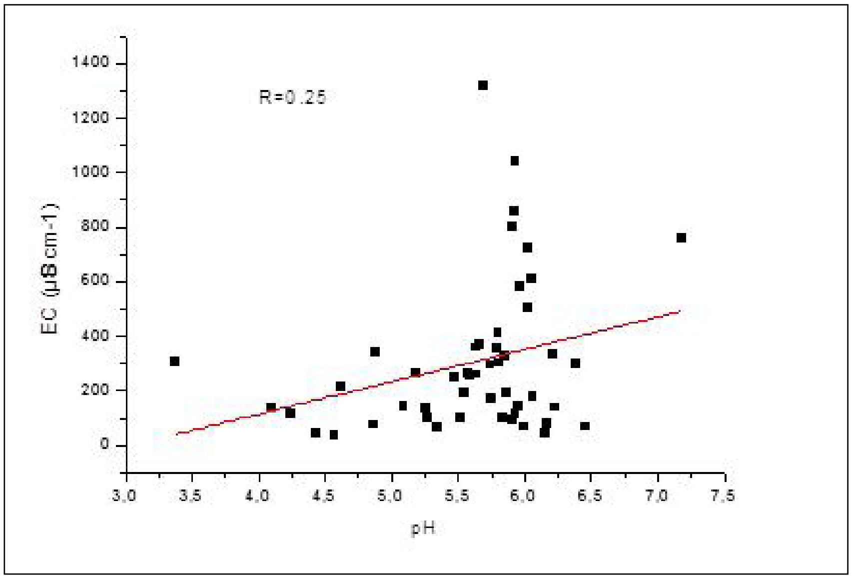

Figure 3. The correlation between *pH* and *EC* values.

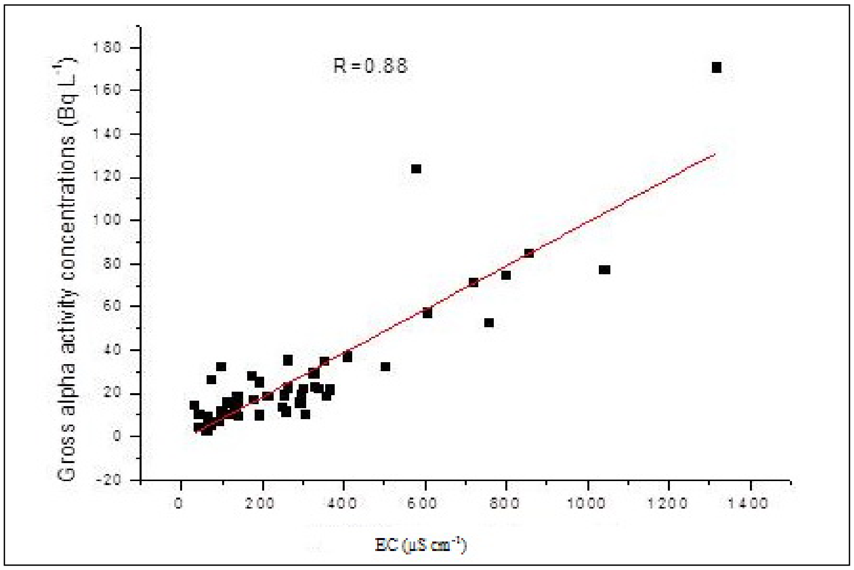

Figure 4. The correlation between the gross alpha activity concentrations and *EC* values.

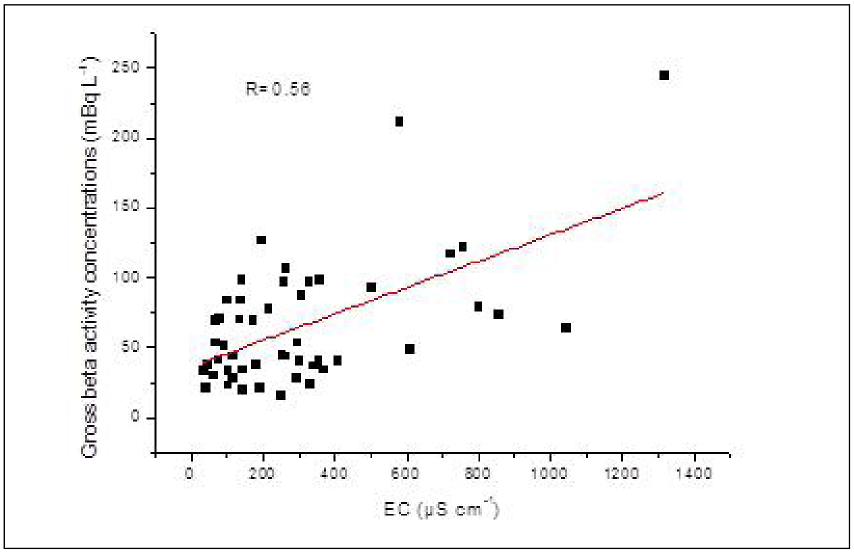

Figure 5. The correlation between the gross beta activity concentrations and *EC* values.

water samples are acidic and are not acceptable for drinking. On the other hand, except a few samples aforementioned in the results and discussion section the other water samples in the region are generally good quality respect to conductivity. The temperatures of the water samples were also found to be close to the temperature of the environmental and therefore, they do not cause any corrosion effect. As a result the most important disadvantage of the water samples in the region is their acidic characters. Adjustment of *pH* of the acidic waters to a range of 6.5–8.5 is advised.

5. Acknowledgements

The authors thank to Bülent Ecevit University since this work was supported by the Project numbered 2014-22794455-01.

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